Chapter 16
Piezometers, Flow Meters, and Level Gauges

16-1. General

Piezometers, flow meters, and water level gauges are utilized in a variety of powerhouse applications to determine flows, water levels, and differential heads. The readings obtained are necessary in the evaluation of turbine performance, operational monitoring, trashrack clogging, fish facility conditions, and for control purposes. All piezometer taps, installed piping, and floatwells are a mechanical design responsibility. However, control designers and structural designers are usually involved with the design process.

16-2. Turbine Piezometers

a. General. Turbine piezometer taps are provided for Pressure-time and Winter-Kennedy tests and to operate flow meters. Applicable embedded provisions are considered justified on all units.

b. Pressure-time provisions.

(1) Applicability. Piezometer taps and embedded piping should be provided for all turbines where the penstock is of sufficient length to meet the minimum requirements. (The majority of Kaplan units do not have suitable intakes for Gibson tests.)

(2) Location of taps. The test section should be located in conduit meeting the following conditions:

(a) Length should be a minimum of 9 m (30 ft).

(b) Length should be greater than two times the diameter.

(c) Length times mean velocity should be less than 200.

(d) Diameter should be uniform.

(e) Bends in the test section should be avoided.

Four taps are provided at each end of the test section. Final location of the test section and taps should be determined by the organization which will make the official Gibson tests.

(3) Tap design. Figure B-18 shows details of the recommended Gibson test piezometer tap.

(4) Piping. An individual line should be run from each tap to a convenient access location in the powerhouse and terminated with a globe valve. All lines should terminate at the same location to permit manifolding. Depending on powerhouse configuration and access, the manifolding location may also be the location for connecting the test equipment. Where this is not convenient, two lines should be run from the manifolding location to the test equipment hookups. Piping will normally be 20-mm (3/4-in.) hard-drawn copper tubing. However, piping must be checked for suitability at maximum conduit head including water hammer. Each line should slope continuously toward the manifolding connections at not less than 2 percent to minimize air pockets and permit purging. Piping adjacent to taps on embedded conduit and spiral case should be arranged and wrapped as shown in Figure B-18 to prevent high stresses from developing following release of conduit pressure after embedment. Also refer to Figure B-18 for typical piezometer piping installation. Consideration should be given to providing bleed valves at high points in the piping system.

(5) Coordination. Coordination of tap and piping installation may be required where tap locations are in a portion of the conduit that is not part of powerhouse design.

c. Winter-Kennedy.

(1) Applicability. Piezometer taps and embedded piping for Winter-Kennedy tests should be provided on all Kaplan and Francis units.

(2) Location of taps. Taps are located on a radial plane near the middle of the first quadrant of the spiral case. One tap is located on the outside wall at the spiral case horizontal center line while one to three taps are located on the inside wall above the stay ring. One outer and one inner tap is required for the tests. However, two additional inner taps are normally provided to aid in achieving the appropriate pressure differential. In steel spiral cases, the taps are normally installed by the turbine contractor. In concrete semispiral cases, the taps are furnished and installed under the construction contract.

(3) Tap design. Tap design should be as shown in Figure B-18.

(4) Piping. Piping provisions noted in paragraph 16-2*b*(4) are applicable except that wrapping of piping is not required with concrete spiral cases. Lines should terminate at location selected for connection of test equipment. See Figure B-18 for typical installation.

d. Net head piezometers.

(1) Applicability. Piezometers upstream of the spiral case are required on all units for use in conjunction with tailwater sensors to determine net head on the unit. Tailwater sensors are covered in paragraph 16-3*b*.

(2) Location of taps.

(a) Francis units. For Francis units, taps are located by the turbine contractor in the spiral case entrance or spiral case extension. Four or more taps are provided in the conduit wall, equally spaced on a plane normal to the flow. Detail of the location and number of taps is determined by the turbine manufacturer.

(b) Kaplan units. For Kaplan units, two taps are located opposite each other in the sidewalls of the turbine intake, about half way between the floor and roof and 1.5-3 m (5-10 ft) upstream of the upstream intersection of the cone with the intake floor and roof.

(3) Piping. Piping should be as noted in paragraph 16-2*c*(4) for Winter-Kennedy taps.

e. Flow meters using Winter-Kennedy taps. Flow meters are used in most powerhouses for measuring and recording turbine discharge. When an in-plant central processor is available, either unit output and net head or output from a differential pressure transducer can be used to calculate flow. Differential pressure can be obtained from the Winter-Kennedy taps for input to the flow meter or central processor.

f. Ultrasonic flow meters. Recent advances have made ultrasonic flow meters a realistic means of measuring flow in Francis and Kaplan units. ASME PTC 18 should be used as a guide for selection and installation of ultrasonic flow meters in Francis units. Manufacturer recommendations should be considered for Kaplan units.

16-3. Miscellaneous Piezometers

a. Trashracks.

(1) General. Where the powerhouse forms a portion of the dam, minimum provisions for monitoring or alarm of high differential heads across the intake trashracks should be considered. Trashrack design may not be based on full clogging of the racks with attendant differential heads so abnormal trash accumulations could cause rack failure. Loss of efficiency due to partial clogging may also be significant. The requirement for a separate trashrack monitoring system is a joint electrical-structural-mechanical determination.

(2) Minimum provision. When the decision has been made to provide an independent trashrack monitoring system, minimum provisions should include a piezometer tap upstream of the racks to sense pool level, a tap downstream of each trashrack, and embedded piping from the taps to a gallery location convenient for connecting to differential pressure switches or manometers. The pool tap should be located in a pier nose, and the tap downstream of the rack should be in a pier wall between the rack and intake gates. Pool tap elevation should be below minimum operating pool, and downstream tap elevation should be at an elevation to record maximum allowable differential across the racks. The control system may be such that the pool level indication could come from the pool level floatwell. When this is practicable, the trashrack upstream pool tap will not be required.

(3) Tap design. Tap design should be as shown in Figure B-18 for concrete installation. If the complete system will not be installed for an indefinite period, a closure plate or plug should remain in place to protect the orifice and embedded piping from silting up. Plate or plug design should permit convenient removal by air pressure or divers.

(4) Piping. Piping should be 20-mm (3/4-in.) hard-drawn copper tubing and should slope continuously toward the gallery connection valve at not less than 2 percent.

b. Pool and tailwater sensors. Where suitable locations for float-type water level gauges are not practicable, bubbler-type pressure sensors have some application. However, with the bubbler-type control, it is difficult to obtain the required dampening without a well, and reliability is not as good as with the float type. Bubbler lines should be sloped as indicated for other piezometer lines and should be provided with a source of clean dry air.

16-4. Water Level Gauges

a. General. This paragraph covers water level gauges of the float type only. Water level gauges based on pressure sensing are covered in preceding paragraphs of this chapter. Gauges of the staff type for visual reading of water levels should be installed in both tailwater and poolwater locations but are normally designed and provided under miscellaneous structural provisions. Float gauges with the floats confined in wells are the preferred type for remote water level indication and control purposes. The required sensitivity (dampening) is readily attainable, and good reliability has been experienced at existing projects.

b. Gauge locations. Gauges are required for tailwater levels and pool levels at all projects and for monitoring and control of fish facility water levels at certain projects. In some cases, more than one gauge may be required to provided accurate measurement. The general location of the gauge will usually be determined by the control function, pool or tailwater hydraulics, or structural considerations. Detail of the location should permit a short straight sensing line, provide safe physical access to top of well, and avoid a sensing line terminating in an eddy where trash concentration and silt deposits are likely. Normally a well location on a pier center line with the sensing line orifice at the outer pier face will be optimum for tailwater and pool gauging. Where the pool gauge will be located in a nonpowerhouse location, coordination of the design with others may be necessary. The top of the tailwater floatwell should be above maximum tailwater.

c. Floatwell design.

(1) Size. The minimum size of a floatwell will usually be determined by the required floatwell to orifice dampening ratio and minimum orifice size to minimize clogging. A 1,000:1 area ratio and 16-mm (5/8-in.) orifice diameter are considered appropriate for most applications. This results in a well of approximately 510-mm (20-in.) inner diameter. The adequacy of the well diameter and length should be verified for the float and counterweight of the intended control.

(2) Material. Floatwell material should be steel pipe and couplings with neoprene gaskets. The sensing line material should be 50-mm (2-in.) Schedule 40 brass pipe.

(3) Installation. Drawings should stress the requirement that the floatwell be smooth and plumb for its entire length. A drain for the instrument blockout at the top of the well should be provided.

(4) Freezing. Where freezing of a floatwell is anticipated, 0.6-0.9 m (2-3 ft) of oil in the top of the floatwell is usually the best solution. An alternative is to provide electric heaters.